

# **Energy-Water Nexus Water Resource Sustainability**



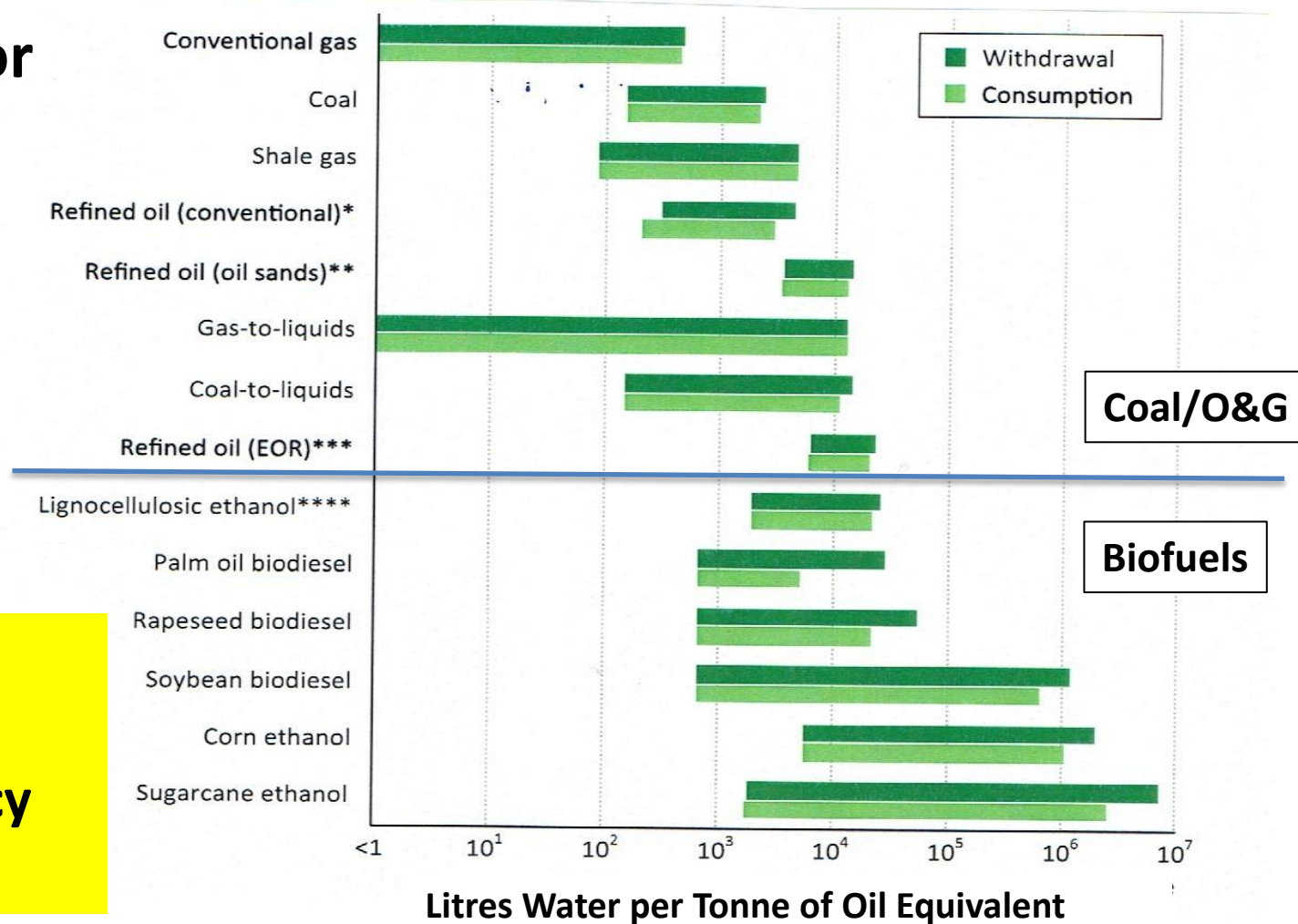
**Linda Capuano, PhD**  
**Center for Energy Studies**  
**Rice University's Baker Institute for Public Policy**

**July 10, 2017**

# Discussion

- **Impact of Water and Energy Interdependence**
- **Growing challenges for fresh water supply**  
Regional economic and social impacts
- **Potential for non-traditional waters to close demand-supply gap**  
Brackish, produced, sea, municipal and industrial reclaimed, runoff ...

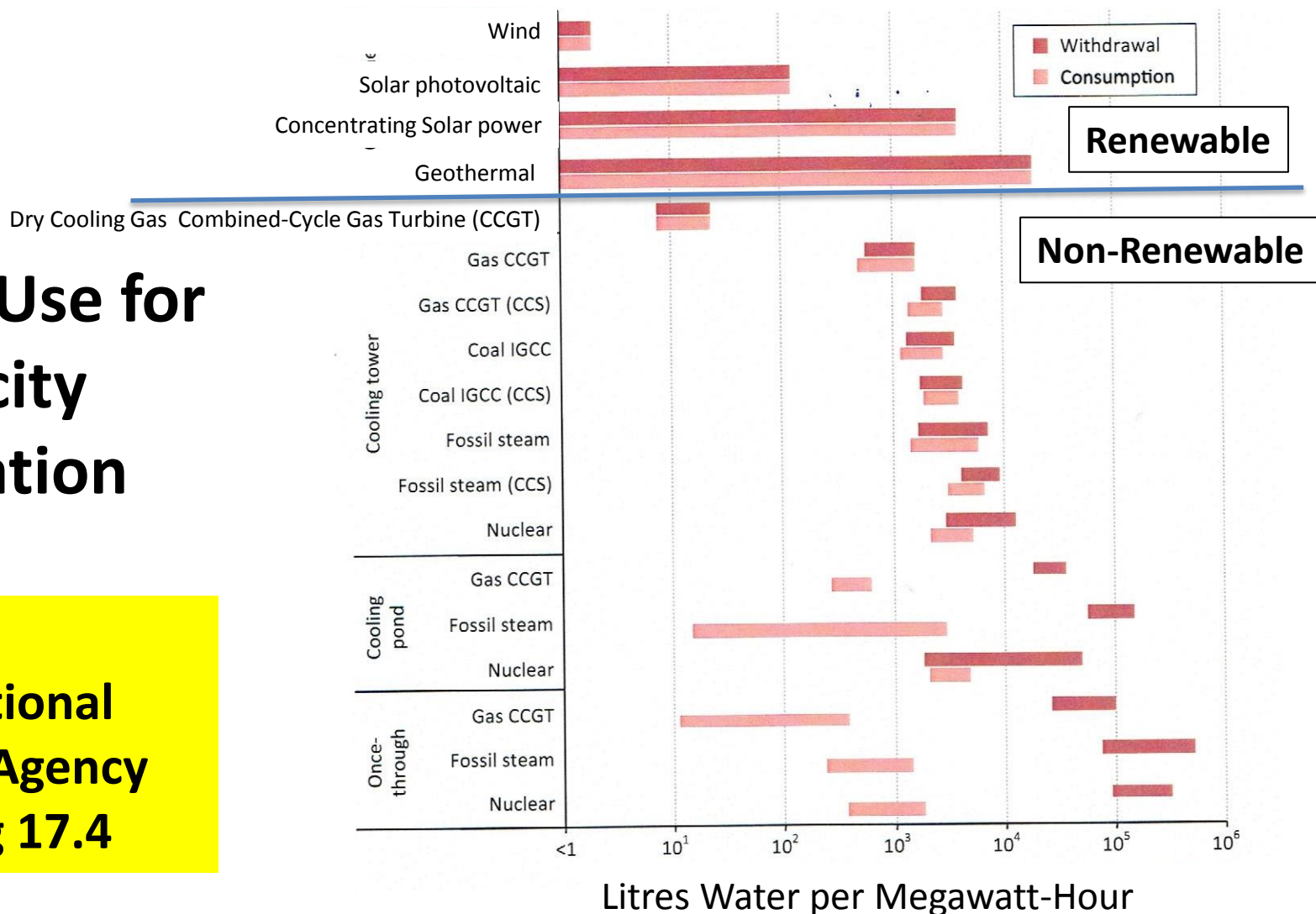
# Water Use for Primary Fuel Production



**2012  
International  
Energy Agency  
(IEA) Fig 17.3**

# Water Use for Electricity Generation

**2012  
International  
Energy Agency  
(IEA) Fig 17.4**

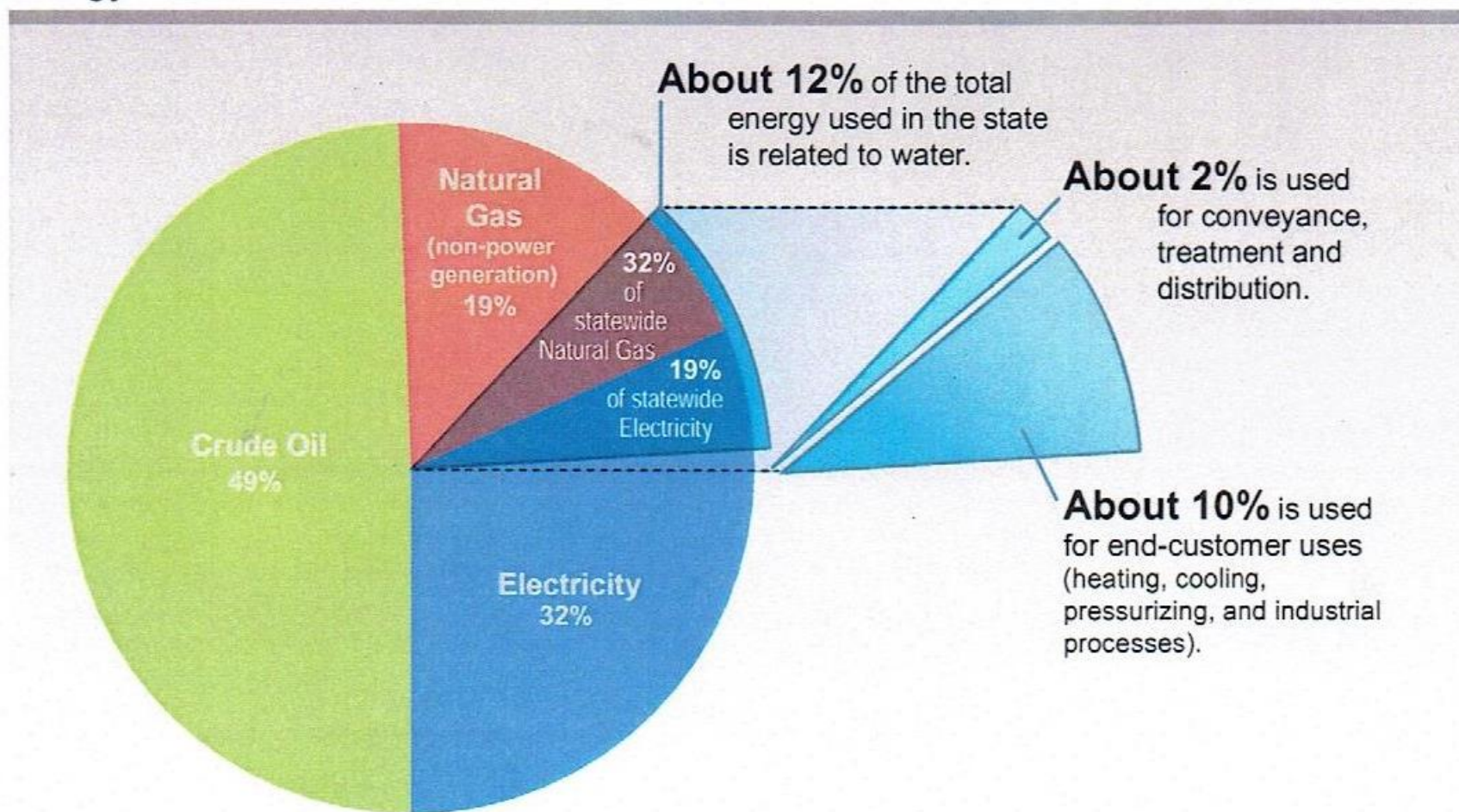


# Water Requires Energy

Water Supply Options	Energy Demand (kilowatt-hour/kilo-gallon)
Fresh Water Transport 100-300 miles	10-18
Seawater Reverse Osmosis Desalination	12-20
Brackish Groundwater Desalination Total	8-10
Reverse Osmosis	7-9
Pumping and concentrate management	1-3
Aquifer Storage and Recovery Total	5-11
Pre-treatment as needed	3-4
Post-treatment as needed	3-4
Pumping	2-3

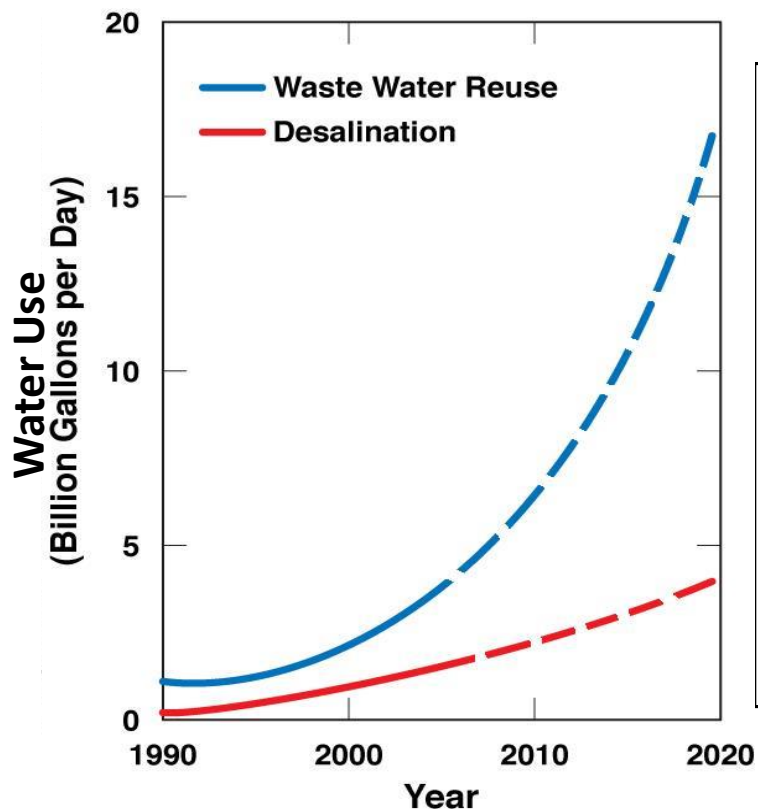


## 2005 California Energy Use Related to Water

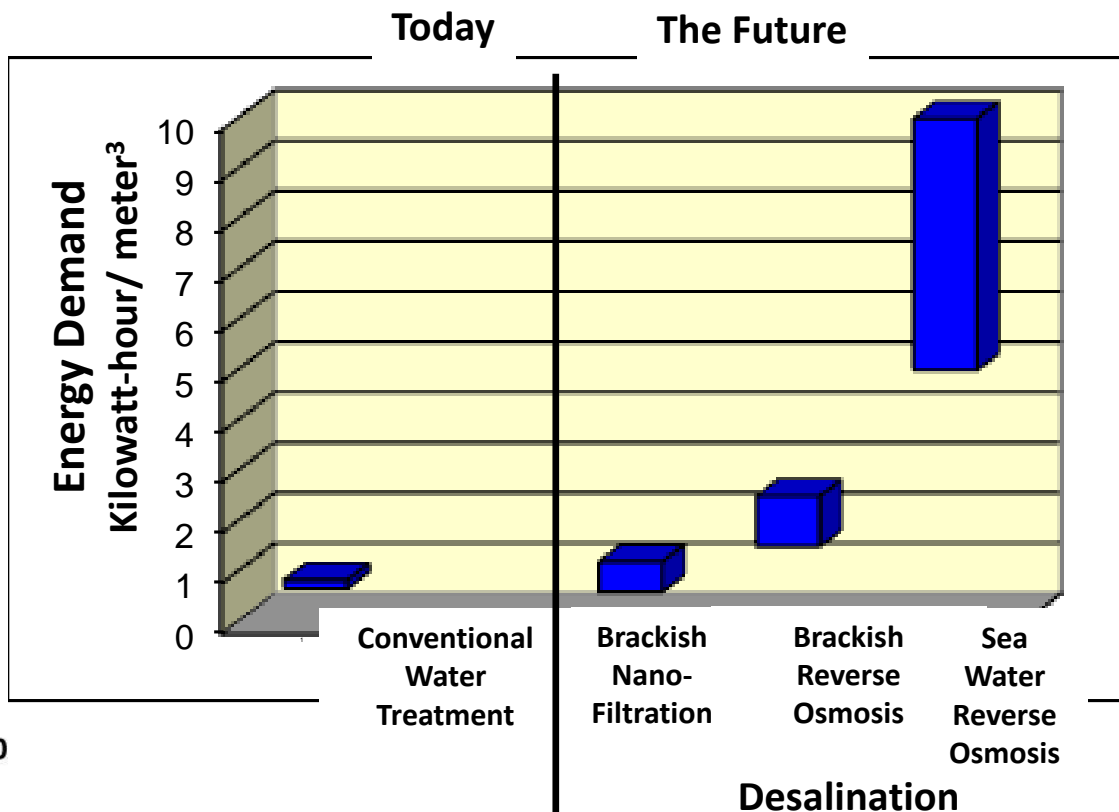


# Non-Traditional Water Use is Increasing

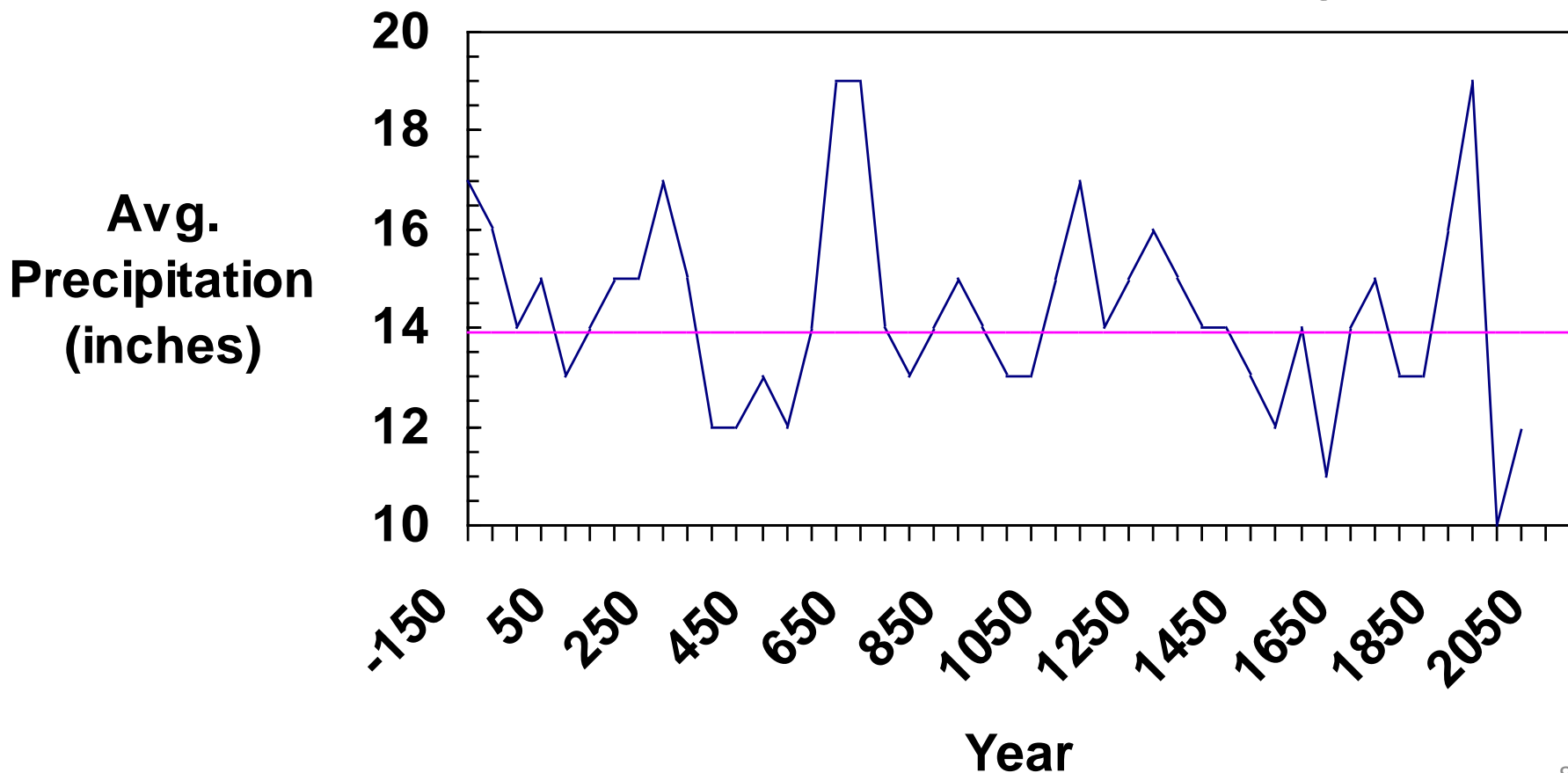
**Projected Non-Traditional Water Use**



**Power Requirements For Water Treatment**



# Tree Ring Data Shows Southern U.S and Mid-Latitudes are in 100<sup>th</sup> Year of 300 Year Arid Cycles

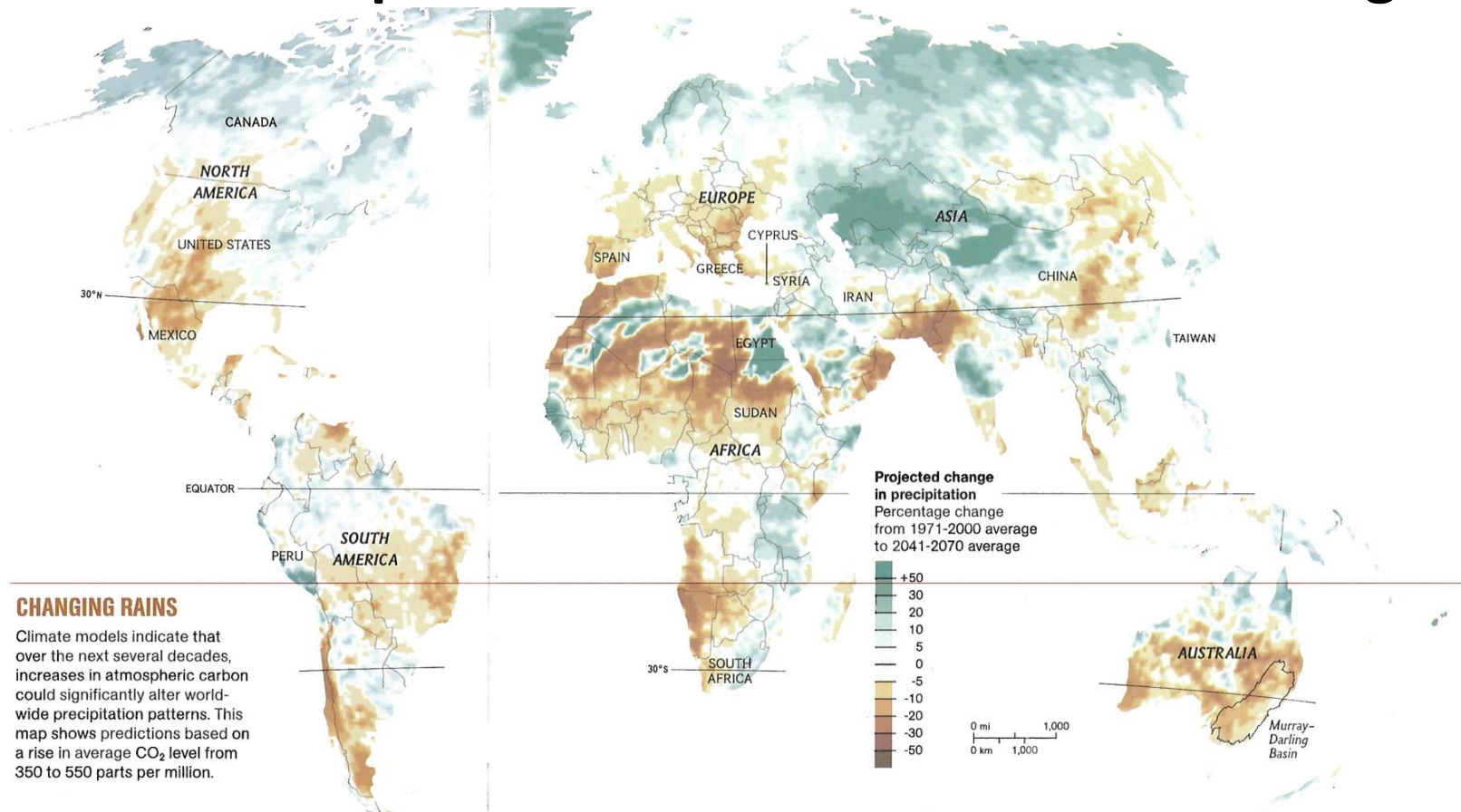




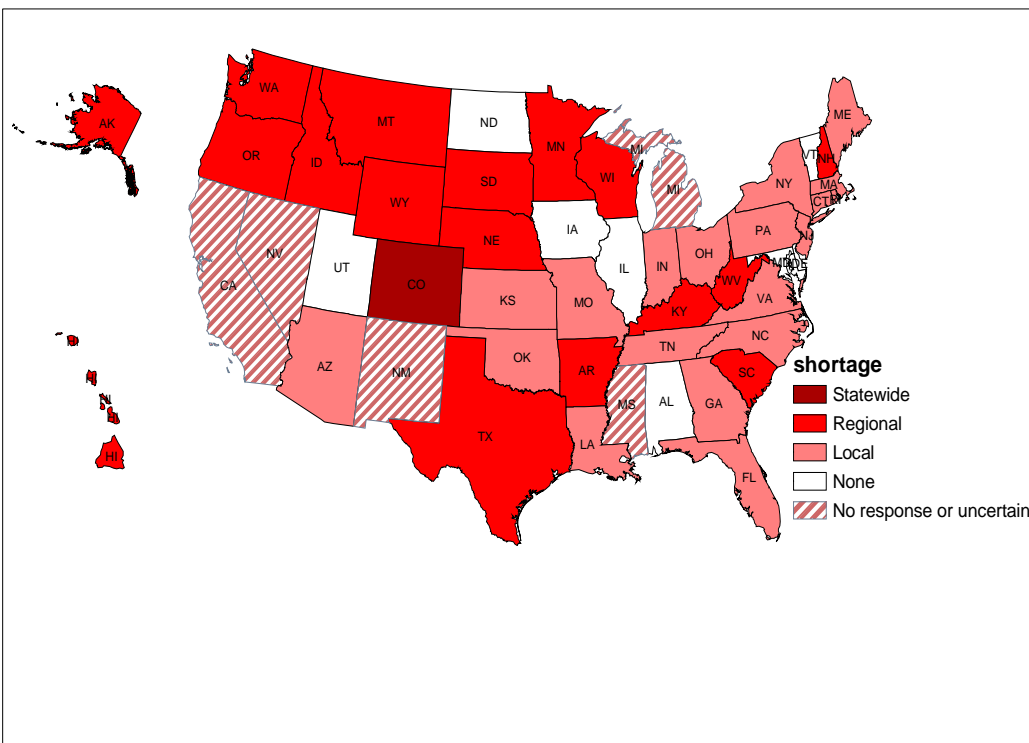
# Impact to Mid-Latitude Population

## Projected Precipitation Change

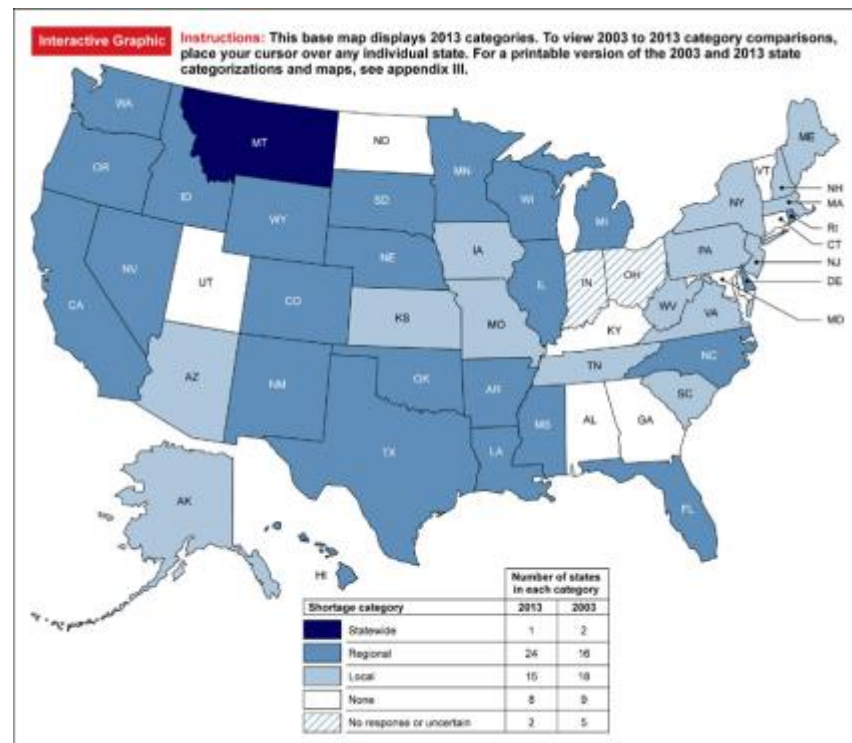
### Compare 1971-2000 to 2941-2070 averages



# Increasing National Water Stress



GAO 2003



Sources: GAO analysis of state water managers' responses to GAO survey; Map Resources (map).

GAO 2013

# Water Demand and Supply Trends

- **Projected state economic and population growth will increase water demand**
- **Look to non-traditional water sources to augment regional supplies.**
  - **Sea water, brackish waters, municipal and industrial reuse, oil & gas produced water, and others can become cost effective**
- **300+ Desalination plants operating in the U.S.**
  - **10% desalination growth per year projected**
  - **15% waste water reuse per year projected**
- **40% of Texas drinking water from non-traditional water by 2050(TWDB)**

Reference: Texas Water Development Board

## Texas Projections

### 70% Population Growth

2020 29.5 million

2070 51.0 million

### 17% Increase Water Demand

2020 18.4 million acre-feet

2070 21.6 million acre-feet

Figure 5.6 - Water use category shares of projected annual water demand in 2020

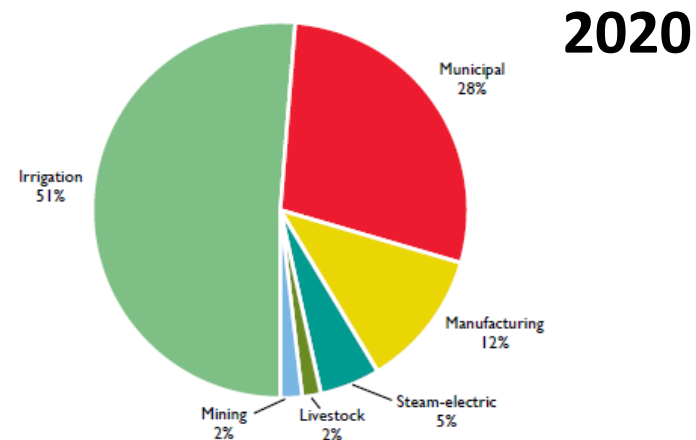
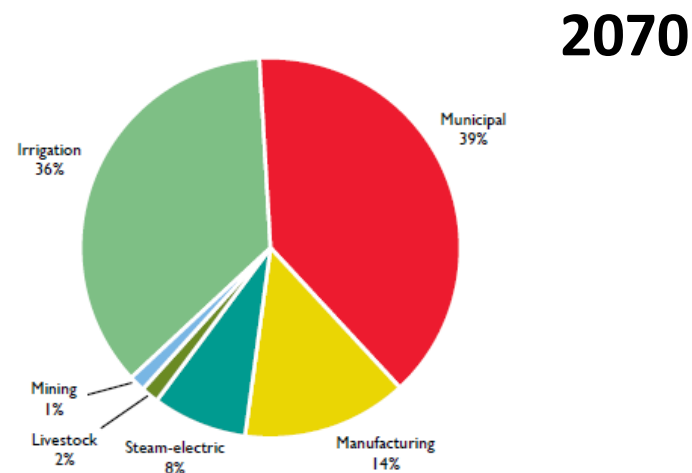


Figure 5.7 - Water use category shares of projected annual water demand in 2070



## Texas Annual Existing Water Supply Projection

	<u>2020</u>	<u>2070</u>	$\triangle$
Total million acre-feet	15.2	13.6	-11%
Surface Water			-1%
Ground Water			-24%
Reuse			+28%

### Potential Water Shortage

2020 4.8 million acre-feet

2070 8.9 million acre-feet

1950s drought of record without developing additional supplies



# Texas Potential Socio-economic Impacts

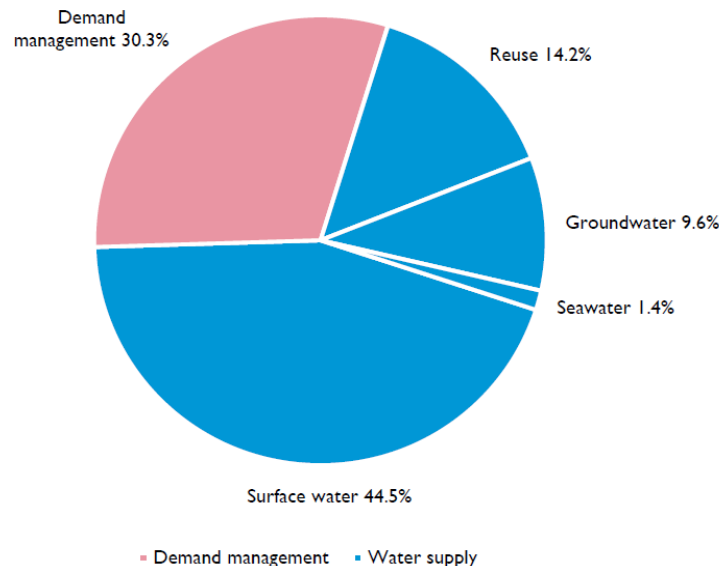
	<u>2020</u>	<u>2070</u>
<b>Income Lost (billions)</b>	<b>\$73</b>	<b>\$151</b>
<b>Jobs Lost</b>	<b>424,000</b>	<b>924,000</b>
<b>Population Lost</b>	<b>78,000</b>	<b>170,000</b>
<b>School Enrollment Decline</b>	<b>14,000</b>	<b>43,000</b>

Estimated temporary socioeconomic impacts that might occur during a single year or record conditions drought if identified water needs (potential shortages) are not met

## Texas Water Plan recommends ~5,500 strategies

- Add ~3.4 million acre-feet/yr in 2020 and 8.5 in 2070
- ~\$63 billion estimated total capital costs (~2,400 projects)
- Includes 26 new major reservoirs by 2070

Figure 8.1 - Share of recommended water management strategies by water resource in 2070



## Produced Water – From Oil & Gas Production

- **Produced Water – 5,000 – 200,000 ppm TDS**
  - 25% < 30,000
  - 25% 30,000 - 60,000
  - 50% > 60,000
- **Also Includes naturally occurring**
  - oils, organic acids, naturally
  - radioactive materials (NORM)
  - boron, beryllium, lithium, hydrogen sulfide, etc
- **Frack Water - Fresh to 250,000 ppm TDS**
- **Flow back water – 10,000 to - 200,000 ppm TDS**
- **Extracted Water – Deep saline waters > 200,000 ppm TDS**



**Western U.S. Produced Water Holding Pond**

	<u>ppm Total Dissolved Solids (TDS)</u>
Fresh Water	$\leq 500$ ppm
Brackish Water	1,000-10,000
Sea Water	$\sim 35,000$

## United States Shale Gas Plays



 Marcellus  
 Utica  
 Devonian (OH shale)

A horizontal scale bar labeled "Miles" at the top center. Below the label, there is a thick black horizontal line. Underneath this line, there are tick marks and numbers: "0" at the left end, "150" at the first major tick, "300" at the second major tick, and "600" at the right end. The distance between 0 and 150 is equal to the distance between 150 and 300, and the distance between 300 and 600 is twice that of the previous segments.



- California
- Colorado
- Oklahoma
- Pennsylvania
- Texas
- Wyoming



## Produced Water Quantities

<b>States with Largest Quantities</b>	<b>Produced Water Production MGD</b>	<b>Available Water @30% Reuse MGD</b>
Texas	860	258
California	353	106
Oklahoma	264	79
Wyoming	250	75
Kansas	122	37
Louisiana	115	35
New Mexico	88	26
Alaska	71	21
Colorado	37	11



# Potential Water Resource Sustainability

## Displacing Fresh Water Use

- **Oil and gas production reuse**
  - Hydraulic fracturing up to 250,000 Total Dissolved Solids (TDS)
  - Steamflooding (California) 5,000 TDS
- **Irrigation – after treatment or dilution**
  - Rangeland rehabilitation up to 12,000 TDS
  - Non-food crops - low boron and 3,000 TDS
  - Algal biofuel production up to 20,000 TDS
  - Support wetlands up to 20,000 TDS
- **Injection/hydraulic control** – reduce subsidence and salt-water intrusion
- **Dust/ice control**
- **Industrial applications**
  - Hybrid cooling towers up to 10,000 TDS
  - Pumped hydro – high TDS
  - Solution mining, wash water

## **Rice Universities' Baker Institute for Public Policy #4**

Among world's university-affiliated think tanks

## **Center for Energy Studies #2**

Among world's energy- and resource- policy think tanks

## **NSF Engineering Research Center**

Nanotechnology Enabled Water Treatment (NEWT)

Modular solar-powered desalination

## Baker Institute's Energy – Water Forum

- **Policies/practices to improve lifecycle water use, conservation and management** – Emphasis on non-traditional, non-fresh waters
- **Interactive forum platform to accelerate timelines**  
Systems level conversations – Sharing successful practices – Overcome barriers and accelerate technological progress – Policy focus
- **Teaming with industry, government, labs and academia**
  - Baker Energy-Water Forum
  - GWPC, NRWA, and other State organizations
  - EWI an Oil and Gas Industry Energy Water Initiative
  - DOE National Labs, and Southwest Regional Partnership
  - Universities

## **Produced Water Forum - Aug 18 2016 – Oklahoma City**

- **OK Governor Mary Fallin, Chair, Interstate Oil and Gas Compact Commission Baker Institute, GWPC, IOGCC States First, and NRWA co-hosted**
- **Experts and key constituents on overcoming challenges to beneficial use of oil & gas produced water**
  - **Chatham House Rule**
  - **End users – including agriculture**
  - **Water producers**
  - **Regulators**
  - **Academia and national laboratories**
- **Recognized the potential for PW to meet some of the growing demand for water in the United States**
- **Considered possibilities and challenges for beneficial use of produced water**

# Priority Challenges

Selected during 2016 Workshop sponsored by Oklahoma Governor Mary Fallin  
GWPC, IOGC, NRWA, Baker Institute under Chatham House Rule

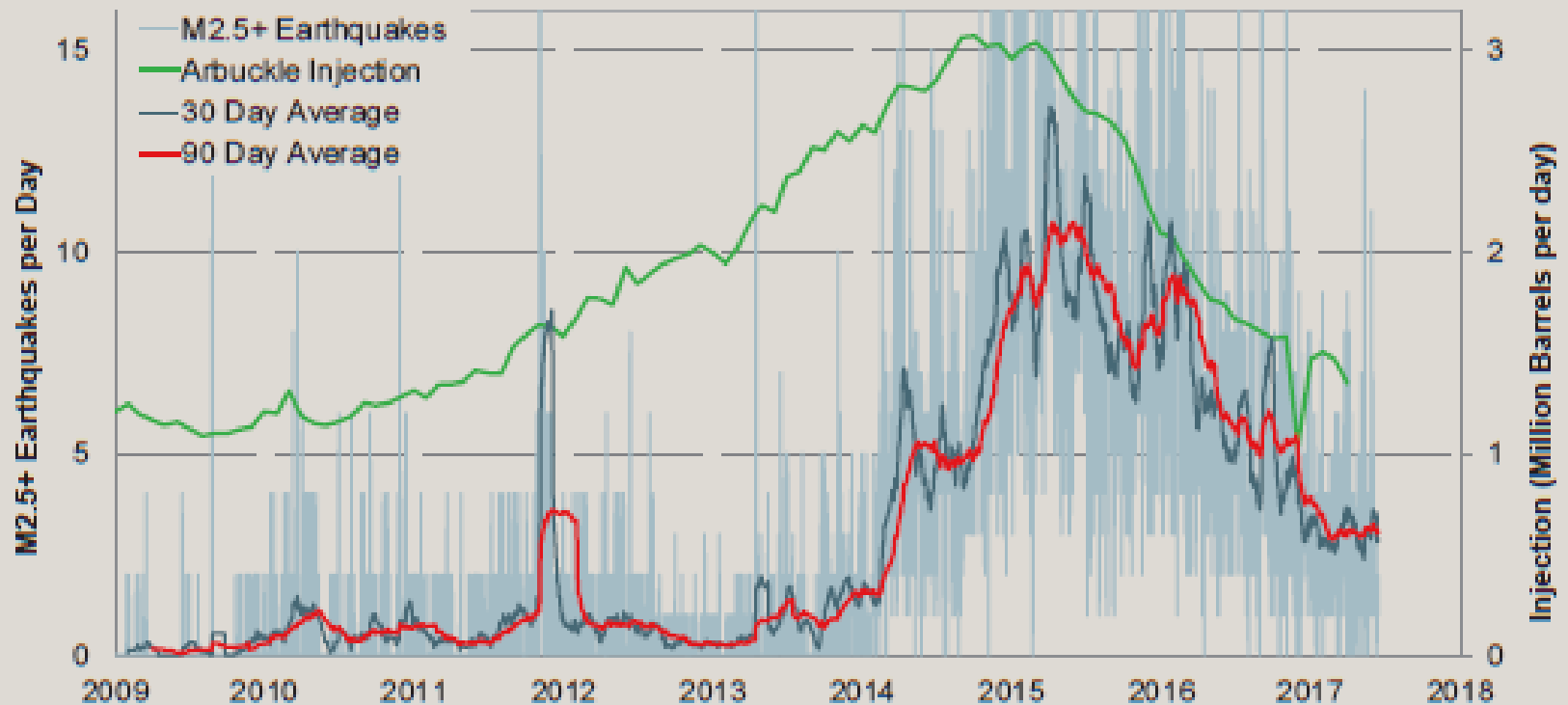
- **Standardized approaches to verify and test new water analysis and treatment technologies supported by impartial and objective guidelines.**
- **Comprehensive modeling methods**
  - **To calculate and compare relative environmental impact, carbon intensity, risk, costs and other characteristics of using produced water when compared to other fresh and non-fresh water sources.**
  - **Includes need to augment associated data bases.**
- **Clarification of PW ownership and liability as it is treated and put to beneficial use.**



## **Additional Important Challenges**

- **Urge states to consider including a more rigorous accounting of O&G PW in their state water plans and identify the effective volume of PW available for use outside the O&G sector.**
- **Encourage centralized discussions to share local, state, and regional success practices in order to accelerate progress in using PW and other non-fresh water sources.**
- **There is a need to communicate and educate companies on the potential benefits of using non-fresh water sources, including O&G PW, as they look to expand or relocate.**
- **There is a need to communicate and educate the public on the potential benefits of using non-fresh water sources, including O&G PW.**

## 4 Oklahoma M2.5+ earthquakes



## Oklahoma Produced Water Working Group

- Report *“Oklahoma Water for 2060 Produced Water Reuse and Recycling,” April 26, 2017*
- Led by the Oklahoma Water Resources Board
- Study and recommend alternatives to produced water disposal from oil and gas operations in Oklahoma.

The *Report* is stated to:

- Constitute a continuation of the implementation of the 2012 Oklahoma Comprehensive Water Plan
- Support the Oklahoma Governor’s initiative to re-use or recycle water produced in oil and gas operations
- Assess the potential alternatives to current practices of injecting produced water from oil and gas wells and disposal wells
- Evaluate the data, issues and opportunities with produced water

## **Key Findings Include:**

- **Produced water re-use by the oil and gas industry is the most viable cost-effective alternative due to minimal water treatment needs and low treatment costs.**
- **A special case of water re-use was evaluated using surplus produced water from the Mississippi Lime play area and was deemed potentially financially competitive (with current disposal methods).**
- **Evaporation techniques for produced water should be further investigated and developed.**
- **Water treatment and desalination techniques of produced water should be further investigated and developed if the Group intends to reduce the majority of water produced in the state.**

## **Report Recommendations Include:**

- **Reduce the challenges to water reuse through targeted regulations and legislation**
- **Further investigate methods to facilitate the re-use of produced water in oil and gas operations**
- **Study further the feasibility of transferring Mississippi Lime produced water to the STACK play**
- **Conduct a more detailed evaluation of evaporation as an alternative to injection**
- **Identify research needs and potential funding partnerships to further accomplish the Group's goals**



## Report Recommendations Include:

- Continue the Group or subgroups to identify opportunities to continue cooperative planning and development of new techniques, infrastructure, water users, legislation and regulatory structure
- Support and build upon the Water for 2060 Advisory Council 2015 energy and industry water use
- sector water conservation findings and recommendations to the Governor and Legislature.

## **Preliminary Legislation related to the topic of produced water:**

[SB 285](#) – (Schulz) Oklahoma Brine and Produced Water Development Act, treats produced water as brine under the act. - *Available for consideration and amendments during 2018 legislative session.*

[SB 287](#) (Griffin) clarifying Clean Water Act jurisdiction of state agencies to handle permitting of PW discharges. - *Signed by Governor*

[SB 475](#) – (Schulz) Expands tax collections on skim oil to treat salt water from produced water the same. - *Failed Deadline – April 27, 2017. Available for consideration and amendments during 2018 legislative session.*

[SB 743](#) (Schulz) creates the Oil and Gas Produced Water Recycling and Reuse Act, requires OCC to identify produced water as hazardous waste and develop rules for recycling and reuse of such waste. - *Available for consideration and amendments during 2018 legislative session.*



Rice University's Baker Institute for Public Policy

[Linda.Capuano@Rice.edu](mailto:Linda.Capuano@Rice.edu)